THEORETICAL ANALYSIS OF THE FAR FIELD RADIATION FROM A COMPLEX SHIPBORNE ANTENNA STRUCTURE

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Closed analytical solutions nearly always fail in cases where the problem is to describe the radiating properties of practical antenna installations. With the ever-increasing number of communication channels, installations tend to comprise several independent radiators, frequently located very close to one another. Regardless of whether such antenna conglomerates are mounted on fixed or mobile platforms, the interaction between actual radiators and supporting structures must be taken into account.

In mobile, particularly shipborne installations the available space is notoriously limited and also confined to areas in close proximity to, for instance, the superstructure of the ship. This leads to strong interaction and, consequently, to serious deformation of the normal distribution of radiated energy. This in turn will usually lead to unexpected field strength patterns in both the near and the far field zones.

Near field anomalies can be of great importance in respect to radiation hazards; not only to human beings but also to nearby electronic equipment, such as fuzing and guidance systems for weapons, a fact that is frequently overlooked. Correlated to such near field anomalies are corresponding irregularities in far field coverage that can seriously impair communication to and from the ship.

Control of both near and far field patterns thus becomes a necessity. In essence this amounts to a need for knowledge of the current distribution, not only over the radiators themselves, but also over the entire supporting structure.

Achievement of this knowledge is a formidable task that has to be approached with caution so as to avoid unnecessary complication and yet permit useful levels of prediction accuracy. In our research group we have looked into both near and far field conditions in a step-by-step approach. The present paper describes some results pertaining to the far field analysis of a particular mast structure.

As was indicated earlier, such analysis requires the use of numerical methods. Two approaches have been considered: the Geometrical Theory of Diffraction (GTD) and the Method of Moments (MoM). The latter was chosen, because of the relation between structural dimensions and wavelength. Several computer programs were developed to perform the calculations. The results presented here were obtained with the aid of a program called "PANT", written in BASIC, in its structure closely related to the rather well-known program "MININEC", which, in turn, ows heritage to the "classical" Numerical Electromagnetics Code (NEC), developed for NOSC by G.J. Burke et al. The program runs quite fast on a Hewlett-Packard 9000 computer.

The example given here pertains to a situation where two vertically polarized ground-plane antennas operating in the 100 to 160 MHz band are mounted "back to back" close to one end of a horizontal yard which is symmetrical about and orthogonal to a vertical mast. The mast is located on a plane conducting substructure and has an additional non-radiating attachment at the joint with the yard (see Figure 1).

The example structure is divided into 17 separate elements, which in turn are sub-divided into a total of 152 segments. The antenna which is mounted "upside down" is driven, while the other is terminated in a 50 ohm resistive load. The operating frequency is 130 MHz and the calculated input impedance of the driven antenna is, under these conditions, 56 + j8 ohms, closely corresponding to the measured value.

The far field radiation pattern was thus calculated for the horizontal plane (polar angle 90 degrees) at azimuth angle intervals of 5 degrees. The same pattern was measured using an old Scientific - Atlanta receiver with a polar recorder. Results are compared in Figure 2, where the solid curve represents measured values of relative power and the calculated values are shown as open circles. All values have been normalized, but no attempt has been made to relate measured and theoretical values with respect to absolute gain.

As can be clearly seen, the qualitative agreement is quite good. There is some asymmetry in the measured curve, due to physical asymmetry in the mechanical arrangement. The obvious difference in the direction of the "main lobe" about zero degrees azimuth is probably due to the fact that the flat structure at the joint between mast and yard has been mathematically approximated by a cylinder, which is a too crude approximation.

Despite these discrepancies the theoretical analysis can be said to be quite satisfactory, since the difference between maximum and minimum power levels is quite accurately predicted. The maximum difference between measured and calculated power in any horizontal direction is about 1.5 dB, including the effects of asymmetry.

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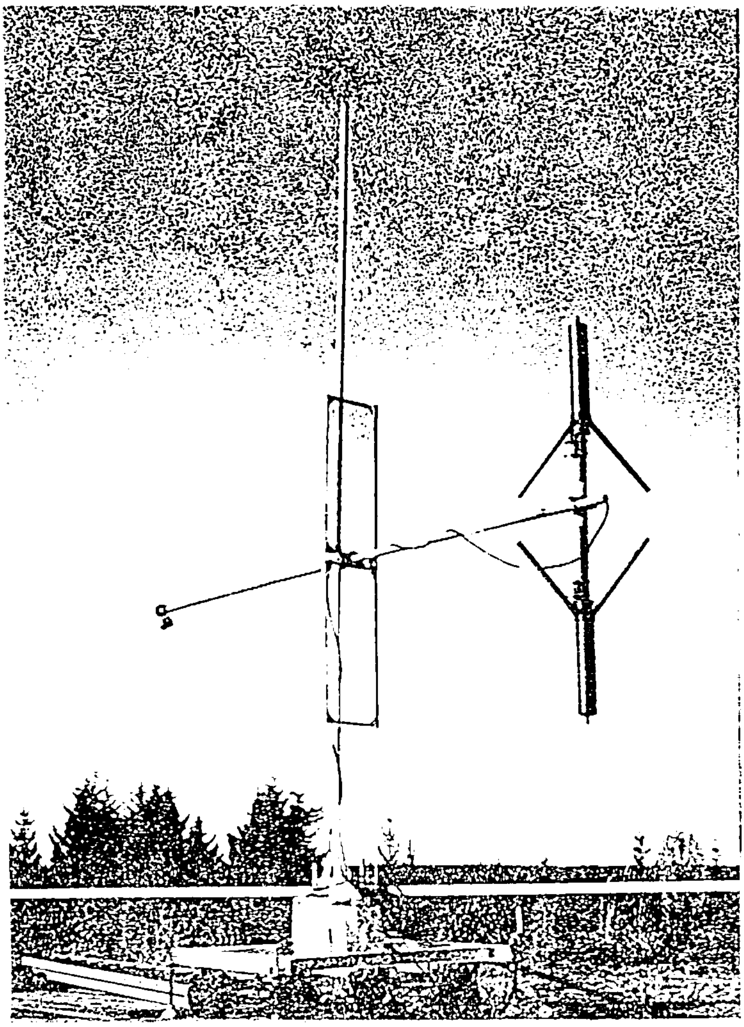

Figure 1. Arrangement for radiation pattern measurement.

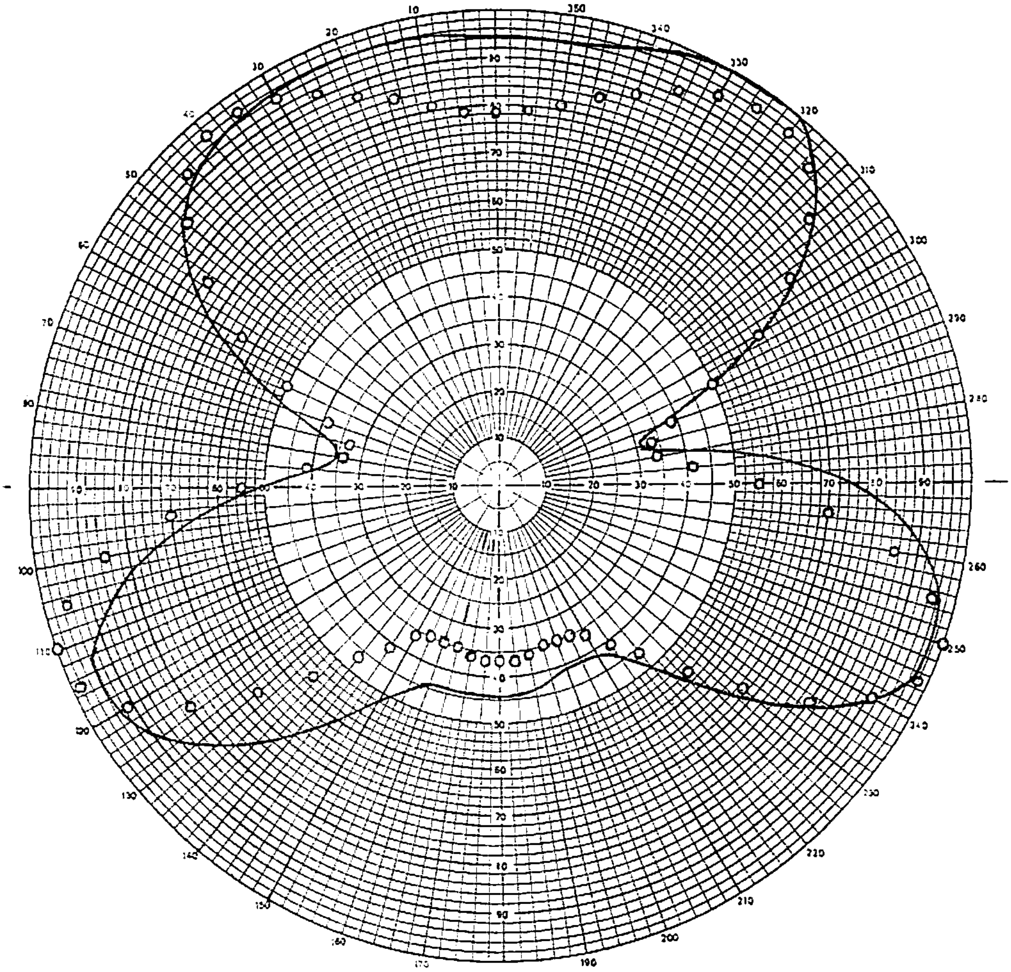

Figure 2. Comparison between measured (solid line) and calculated (circles) radiation pattern; horizontal plane.